



HFACS REPORTS



A Quarterly Newsletter of Marine Facility Incidents using The Human Factors Analysis & Classification System

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What is HFACS?

A tool for analyzing the causes of marine facility spill incidents in human and organizational terms can assist spill prevention efforts.

Marine Facilities Division of the California State Lands Commission (CSLC) has been using the *Human Factors Analysis and Classification System (HFACS)* to guide its oil spill and violation incident inquiries since May 2001. HFACS was developed by Scott Shappell and Doug Wiegmann (2000) as a tool for analyzing the role of human error in civil and military aviation accidents, and it easily adapts to describe incidents in marine facility operations.

Layers of Defenses Like Slices of Cheese

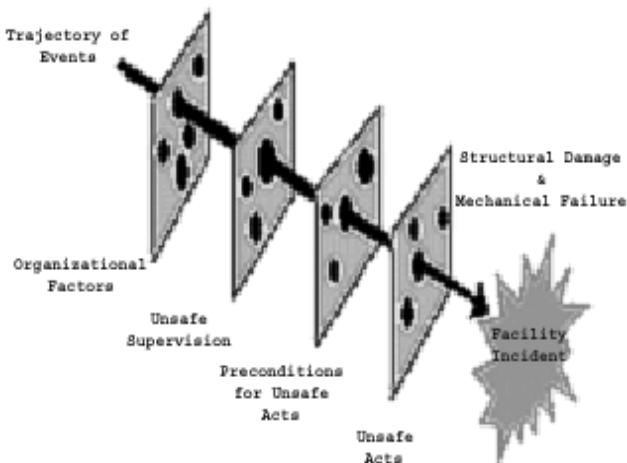
HFACS is based on the idea that the actions of operators and failures of equipment and structures that unfold during an event – termed *active failures* – combine with preexisting factors, or *latent conditions* to trigger an incident. The policies, procedures, resources (people & parts) and activities that comprise a marine facility operation are designed as *layers of defense*, aimed at completing a job successfully while preventing an adverse incident in the process.

Active failures are really weaknesses in the first line of defense, while latent conditions are weaknesses in the second, third and fourth lines of defense. Jim Reason (1990), who has studied the role of human and organizational error in a number of industrial settings, suggests we think of these weakened layers of defense as slices of Swiss cheese. Each layer of defense is like a slice of cheese, and active failures and latent conditions are like “holes” in each slice. Applying this view to oil spill incidents, it takes a trajectory of events, passing through a hole in each slice of cheese, or layer of defense, to trigger an oil spill incident (see figure below).

Identifying The Holes

CSLC’s version of HFACS follows directly from the ideas just outlined, and it is defined in more detail in the section titled *Classifying Incidents with HFACS*. Contributing causes of incidents are organized into layers of defense (slices of cheese), and the factors or causes listed represent the weaknesses (or holes) in the defenses. The intent is to point out and localize holes that need to be filled in order to strengthen overall system defenses against oil spill incidents.

For each incident, the classification of contributing causes into HFACS terms is triggered by either a report of a spill that occurs at a marine facility or the issuance of a class 3 violation by a CSLC Inspector. An inquiry is conducted by Division Marine Safety Specialists in conjunction with the Inspectors. In addition to on-scene observation and interviews with involved parties, notes that may be contributed from either the facility or vessel’s own internal investigation, when available, are considered in determining what caused the incident. For each case, a brief de-identified narrative text is followed by a listing of each causal factor. The section *Selected Cases* illustrates how narratives and causal factors are reported.



Classifying Incidents with HFACS

This section is a reference guide. Definitions of the major classifications and subtypes used in HFACS to classify contributing incident causes are given. Examples of its use are given on the back page of the newsletter.

LAYER 1: UNSAFE ACTS

Unsafe acts are operator actions (or inaction) that occur *immediate* to, and often trigger an adverse event. HFACS considers two broad types of unsafe acts, errors and violations.

Errors are the mental and physical activities of an individual that fail to achieve an intended outcome. Errors occur within the rules and regulations. Errors are further divided into 3 types. **Decision** errors occur when a situation is not recognized or misdiagnosed, or when in unfamiliar situations an unsuccessful procedure is applied. **Skill-based** errors occur during execution of a familiar procedure, and often result from a lapse in memory (e.g., forgetting a step) or attention (distraction from another task). **Perceptual** errors are misinterpretations of what is seen, heard or otherwise taken in through the senses.

Violations, in contrast to errors, are willful violations of the rules and regulations. **Routine** violations are instances of breaking the rules & regulations that are part of a behavior pattern. These “shortcutting” behaviors are often condoned by management. **Exceptional** violations are not typical of an individual, are typically not condoned by management. These “one-time” offenses may or may not involve malice.

LAYER 1: STRUCTURAL DAMAGE AND MECHANICAL FAILURE

Structural damage and mechanical failure refer to damage or malfunctioning of equipment, structures, work spaces that are immediate to, and often trigger an adverse event. Broken hoses, corroded pipelines, leaky valves, malfunctioning gauges are all examples of this broad class of causes. HFACS further classifies these events depending whether they occur in vessel or terminal equipment, and whether the damage is structural or functional.

LAYER 2: PRECONDITIONS FOR ADVERSE EVENTS

The second layer of defense includes existing conditions and practices of operators, as well as the prevailing state of the workspace and environment. While problems at this level are present at the time and place of an incident, they are not immediate causes or triggers of the incident. Weaknesses in these defenses can be thought of as lost opportunities for preventing an incident, and can therefore become opportunities for preventing future incidents. There are four major categories of preconditions and HFACS divides each category into several subtypes.

Substandard conditions of operators are states or characteristics of operators around the time of an incident that predispose the individual to error. Of these, **adverse mental states** are physical & mental conditions (e.g., loss of situational awareness, complacency, misplaced motivation, effects of sleep loss) that negatively affect performance. **Adverse physiological states** include physical fatigue, illness, intoxication and medication effects that are known to influence performance. A third subtype, **physical/mental limitations**, are sensory, motor or cognitive

limits that result in “not seeing”, “not hearing”, “not understanding” or “not acting quickly enough” to safely complete an action or procedure.

Substandard practices of operators are failures of individuals or groups to adequately prepare for and communicate during work activities. HFACS considers two subtypes under this general category.

Crew resource management issues are instances of poor crew coordination, communication, or direct supervision that result in unsafe behavior. **Personal readiness** include instances either of poor judgment in maintaining readiness for work (e.g., using time for adequate rest) or violation of any existing work readiness rules.

Substandard work interfaces are instances of design or maintenance of equipment and work spaces that are inadequate for safe work and secure transfer and storage of oil. Subtypes of work interface issues include problems with **design** of structures and problems with **maintenance** of structures.

Adverse environmental conditions are prevailing weather, temperature or sea conditions that interfere with perception, communication or actions necessary to carry out safe operations.

LAYER 3: UNSAFE SUPERVISION

The third layer of defense, **unsafe supervision**, refers to supervisory practices or decisions, often removed from the time or place of the incident, that are inadequate to ensure safe and secure functioning of an operation. There are four subtypes in this classification. **Inadequate supervision** refers to instances when supervisors fail to provide adequate training opportunities, guidance, leadership or motivation. **Planned inappropriate operations** are approved operations or activities carried out in haste that often result from the pressure of production outweighing the need for protection. **Failure to correct a known problem** is a third type of unsafe supervision that includes deficiencies among individuals, equipment, training or procedures that are known to a supervisor, but that are allowed to continue unabated. **Supervisory violations** are instances of willful disregard of the rules, or a failure to enforce rules and regulations.

LAYER 4: ORGANIZATIONAL INFLUENCES

The final layer of defense, **organizational influences**, are often omitted in incident inquiry programs, but they can directly affect both supervisory and operator practices, as well as the physical and cultural environment of an operation. **Resource management** issues include the sufficiency of human, equipment and monetary resources supplied an operation to safely and effectively operate. **Organizational climate** refers to instances when the “work atmosphere” is substandard for conducting a safe and effective operation. The willingness to report errors, clarity about acceptable and unacceptable behavior, flexibility to respond to incidents and learn from mistakes are all examples of a good organizational climate. Finally, **organizational process** refers to the adequacy of policies that guide everyday operations. (e.g., operating procedures, incentive systems that strain safe operation).

Data: May through December 2001 Summary Statistics

- 25 of 29 incidents that occurred between the second week of May 2001 (when HFACS was implemented) and the end of December 2001 are included in this report. Inquiry and analysis of the remaining cases had not been completed at the time of publication, but will be added to totals for this baseline period in the next quarterly newsletter. Incident totals were as follows:

Incident Type	Count (%)
Spills	20 (80)
Class 3 Violations	5 (20)
Total Incidents	25

- There were a total of 87 contributing causes associated with the 25 incident cases. The first column of figures shows the number and percentage of each contributing cause type. The second column shows the number and percentage of incidents having at least one instance of each cause type.

Contributing Cause	Number (%)	Number (%) of cases w/ at least 1
Struc. Damage/Mech. Failure	14 (16)	13 (52)
Unsafe Acts	22 (25)	17 (68)
Preconditions for Adverse Events	23 (26)	16 (64)
Unsafe Supervision	19 (22)	14 (56)
Organizational Influences	9 (10)	7 (28)

• *Data will appear regularly in HFACtS Reports and feature a statistical summary of major error types. **Quick Facts** (see below) will regularly feature patterns that emerge from looking at combinations of*

Quick Facts

- Substandard maintenance was a contributing cause in 54% of the cases that involved structural damage or mechanical failure.
- Both terminal and vessel organizations were the source of at least one causal factor in 5 (20%) of the total number of spill cases

Problems & Solutions

In this section, HFACtS Reports will feature a discussion of a selected, recurring and preventable problem observed in recent incidents involving marine facilities.

Could leaks from two aging marine oil terminal pipelines have been prevented by following CSLC pipeline integrity assessment requirements?

For "oil" pipelines which are above ground or over water and which do not have secondary containment or cathodic protection, CSLC requires two measures to ensure pipeline integrity assessment: (1) a static liquid pressure test (SLPT); and (2) an API 570-based preventive maintenance program (PMP). Both the SLPT and PMP are focused on detecting moderate to severe defects in a pipeline. In two instances where pipeline leaks occurred during this reporting period, the separate pipelines had undergone annual SLPT; however, PMP had not been implemented. PMP

includes: (1) taking a representative sample of pipeline wall thickness measurements; (2) estimating remaining life of the pipeline based on wall thickness measurements; and (3) performing a comprehensive exterior visual inspection.

The reported leaks both occurred from pinhole-sized defects in a straight section of pipeline. Both pipelines were either wrapped or insulated which would have impaired any visual inspection. A conventional ultrasonic point-type wall thickness survey is unlikely to detect a pinhole-sized defect because of the limited number of measurements taken and the fact that most measurements would be concentrated at or near fittings or transitions in the pipeline where accelerated corrosion and erosion is most expected. However, other previously undetected moderate or severe defects could have been discovered during a conventional ultrasonic wall thickness survey. This discovery would have alerted terminal personnel that perhaps the surveyed pipeline required repair or replacement.

A new innovative type of ultrasonic test screening tool

using low frequency guided waves qualitatively surveys the entire pipeline for defects. If this test was used at the terminal prior to the leaks, it may have uncovered the leak-causing defects. This pipeline testing technology was used at the terminal on a removed section of pipeline following the second leak event. The results have been shared with CSLC

and reportedly at least two severe pipeline defects were discovered.

For further information on preventative maintenance programs, available pipeline testing techniques, or terminal pipeline program requirements and guidelines, contact Michael Edwards, PE of CSLC Marine Facilities Division at (562) 499-6312 or email edwardm@slc.ca.gov.



Selected Cases

1. Following completion of a loading operation, corrosion of an approximately 40 year old dedicated terminal gasoline pipeline caused a ½” wide X 1/16” long crack, spilling gasoline into the water. The line was idle but full of product when the leak was discovered. Because the line that leaked is wrapped in tape to arrest corrosion, visual inspection for leaks – the method used to monitor the integrity of lines during normal operations at this facility– was precluded. The TPIC was able to detect the leak only after product had saturated the insulation and spilled into the water.

Who/What	Factor	Classification	Subclass 1	Subclass 2	Detail
terminal pipeline	leaked gasoline as the result of corrosion	structural or mechanical damage/failure	terminal	structural	pipeline
TPIC	failed to detect defect in pipeline	unsafe act	error	perceptual	failure to see hear or otherwise sense
ops supervisor	failed to require close manual inspection of pipeline each shift	unsafe supervision	failed to correct a known problem		failed to identify an at-risk procedure
pipeline wrap	precluded visual inspection for pipeline integrity	precondition for adverse event	substandard work interface	substandard maintenance	poorly maintained equipment
terminal	failed to assure the integrity of aging pipelines throughout facility	organizational influence	resource management		inadequate design & maintenance of facilities

2. A tanker barge was moored starboard alongside a marine terminal wharf, and a tug was moored starboard alongside the barge. The tug agreed to transfer a small parcel of diesel oil to the barge shortly after the barge completed cargo transfer operations with the marine terminal. The vessel to vessel transfer was arranged without knowledge of the marine terminal. Tug personnel connected a transfer hose from the starboard filling pipe to the filling pipe on the barge. Once the transfer began, the port filling pipe on the tug – capped with a cam-lock coupling, but without a gasket – became pressurized, and fuel began leaking from it onto the main deck of the tug and into the water. This transfer occurred without a pre-transfer conference and without a signed declaration of inspection.

Who/What	Factor	Classification	Subclass 1	Subclass 2	Detail
hose end cam-lock fitting	leaked fuel as the result of a missing gasket	structural/mechanical damage/failure	vessel structural		flange/gasket
tug crew	failed to keep transfer hose fitting in proper repair prior to conducting fuel transfer.	precondition for adverse event	substandard work interface	substandard maintenance	poorly maintained equipment
tug & barge captains	conducted transfer at marine terminal without informing terminal personnel.	precondition for adverse events	substandard practices of operators	crew resource mgt.	failed to conduct adequate brief
tug crew	failed to attend to detail during hastily conducted connection and transfer procedures	substandard conditions of operators	precondition for adverse events	adverse mental states	haste

References and Contacts: This newsletter is available for download at <http://www.slc.ca.gov>. General information about human and organizational error in industrial operations can be found in Reason, J. (1980) *Human Error*. New York: Cambridge University Press; and Shappell, S.A/ & Wiegmann, D.A. (2000). *The Human Factors Analysis and Classification System – HFACS*. FAA Office of Aviation Medicine Report # DOT/FAA/AM-00/7. Washington, D.C.: Department of Transportation, Federal Aviation Administration. This newsletter was composed by Maria Gutierrez. Questions about the content of this newsletter or about HFACS can be addressed to Marc Chaderjian, Research Program Specialist I, chaderm@slc.ca.gov (562) 499-6312.



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